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Assessment of the Division 4VWX and Subarea 5 Pollock Stock Complex

by

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Abstract

Nominal catches of pollock have consistently exceeded the TAC since 1977: the 1980 provisional nominal catch was 55,000 mt. Canadian R.V. survey and commercial catch rates indicate substantial increases in stock size since 1976, whilst U.S.A. R.V. surveys indicate relative stability. Three year running averages of Canadian commercial catch rates in June-July and August for both TC4 and TC5 were used to fine tune cohort analysis for ages 5 and older. The average partial recruitment for ages 2 to 4 between 1973 and 1976 was used to estimate the sizes of the 1976 to 1978 year-classes. A 1980 fully recruited fishing mortality of F = 0.275, with the P. R. vector mentioned above, was found to best represent the 1980 stock status. Projections at $F_{0.1}$ in 1981 and 1982 indicate catches of 54,000 and 55,000 mt respectively, whereas the 1982 $F_{0.1}$ catch would be 58,000 mt if the presently set 1981 TAC (40,000 mt) is not exceeded.

Résumé

Les captures nominales ont été supérieures au TPA depuis 1977 et ont atteint 55 000 tm en 1980. Les campagnes d'échantillonnage scientifique canadiennes et les taux de captures de chalutiers arrières canadiens indiquent une forte aumentation du stock depuis 1976 alors que les données des campagnes américaines suggèrent une relative stabilité. Des moyennes mobiles de trois ans des taux de captures commerciaux des chalutiers arrières canadiens (classes de tonnage 4 et 5 séparément) ont été utilisées pour adjuster les nombres de 5 ans et plus de l'analyse de cohorte. Les recrutements partiels moyens à 2, 3 et 4 ans de 1973 à 1976 ont été utilisés pour estimer la tailles des classes d'âge de 1976 à 1978. Ce vecteur de recrutement partiel et un taux de mortalité par pêche en 1980 de F = 0,275 sur les âges pleinement recrutés a semblé donner la meilleure représentation de la taille du stock en 1980. Des projections au niveau $F_{0.1}$ indiquent des captures de 54 000 et 55 000 tm en 1981 et 1982 alors que la capture au niveau $F_{0,1}$ serait 58 000 en 1982 si le TPA de 1981 (40 000 tm) n'était pas dépassé.

Introduction

Pollock within Subareas 4 and 5 were first brought under quota management in 1973, when a pre-emptive TAC of 50,000 mt was established for Division 4X and Subarea 5. A single management unit was thought to be justified because only one major spawning area, on Jeffrey's Ledge (Div. 5Y) (Steele 1963), had been identified. It was later noted that a portion of the catches were consistently taken in Divs. 4V and 4W (Halliday 1973). Subsequent management recommendations were thus made for Divs. 4VWX and Subarea 5, taking into account the fishery in Statistical Area 6.

Nominal catches of pollock fluctuated between 37, and 41,000 mt from 1961 to 1965, and 23, to 26,000 mt from 1967 to 1971; they rose again to 34,000 mt in 1972 and 43,000 in 1973 (Table 1). The ICNAF Assessment Subcommittee concluded from these data and commercial catch rates that the decrease in catches during the late 1960's and early 1970's represented a decline in the stock followed by an increase in abundance in 1972 (ICNAF Redbook 1973, p. 77). It was suggested that the 65% increase in catches during 1972 compared to 1971 (Scott, 1973) could be explained by a diversion of effort towards pollock as a result of concommittant restrictions on the haddock fishery in Div. 4X. The TAC for 1974 was increased to 55,000 mt to take into account expansion of the quota management area to included Div. 4VW.

In 1974 and 1975 the Canadian and USA commercial catch rates and nominal catches increased (ICNAF Redbook 1974, p. 91; ICNAF Redbook 1975, p. 37), although research vessel survey indices of abundance fluctuated considerably, and showed at best only a slight increase in biomass. It was again concluded that "shifts in directed effort associated with recent declines in the SA 4 and 5 haddock stocks were primarily responsible for the increases in nominal catches and catch rates observed in recent years" (ICNAF Redbook 1975, p. 37). The TAC's for 1975 and 1976 were therefore kept at 55,000 mt, even though they were undercaught in both 1974 and 1975.

The delineation of stocks in Subareas 4 and 5 was reviewed in 1976, and the presence of local spawning stocks noted for Subarea 4 (ICNAF Redbook 1976, p. 178). However, the information available was still considered insufficient to provide support for separate TAC's for the different areas. Estimates of fishing mortality indicated a rise beyond F_{max} = 0.4 (with natural mortality of 0.2) during 1974-76. Decreases in the U.S.A. trawl survey and Canadian commercial indices of abundance were also noted, and taken to indicate that the 1972-74 year-classes were weaker than those of 1968, -69 and -71 and that recruitment prospects for 1977 would be smaller than average. The TAC was reduced from the pre-emptive TAC of 55,000 to the calculated F_{max} level of 30,000 mt for 1977.

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In 1977 the CAFSAC Groundfish Subcommittee again concluded from research vessel and commercial data that the more recent year-classes appeared to contain less than half the number of recruits (20×10^6 at age 2) compared to the numbers estimated for the 1971 year-class (45×10^6 at age 2) (CAFSAC Advisory Documents 1977-1978, p. 38). The TAC for 1978 was thus maintained at 30,000 mt. Nominal catches for 1978 however exceeded the TAC by 15,000 mt. This sudden rise in catches was attributed to the unrestricted American fishery which had shown an increased diversion of effort probably in response to restraints on other groundfish stocks (CAFSAC Advisory Documents 1979, p. 54). There was also some concern expressed by the Groundfish Subcommittee that the 1977 catch rates and hence calculated fishing effort were "substantially biased by increased availability", because the "1978 research data showed no further decline or increase of abundance compared to 1976". (CAFSAC Advisory Documents 1978-1979, p. 136). Thus the TAC for 1979 was maintained at 30,000 mt.

In 1979 the nominal catches exceeded the TAC by 17,000 mt. The CAFSAC Groundfish Subcommittee noted substantial increases in population biomass and potential yields, however, these were not confirmed by reports from the Canadian fishery. Such uncertainties combined with an unknown level of misreporting of haddock for pollock led CAFSAC to advise on a preliminary TAC of 30,000 mt for 1980. This was subsequently reviewed on the basis of research and commercial data collected in 1979, and the revised estimates of stock status resulted in the TAC being increased to 40,000 mt.

Nominal Catches

The 1980 nominal catch is given provisionally at 55,000 mt. This level represents the highest catch in the history of this fishery, and represents an increase of 19% over the 1979 catch (Table 1). In 1980 foreign nations reporting pollock landings from Div. 4VWX and 5 included Japan, USSR, France, Federal Republic of Germany and Cuba, but their contributions to the nominal catch was less than 2%. The remaining 98% was taken by Canada and the U.S.A., contributing 65% and 33% respectively.

Historically these two countries have been the main harvesters of pollock contributing 61-100% to the total landings in the period 1960-1980 (Tables 1 and 2). Foreign nations also involved in the fishery have included Federal Republic of Germany, German Democratic Republic, Japan, Spain, USSR, France, United Kingdom, Portugal and Cuba, of which the USSR has taken the greatest proportion. Since 1977 and the establishment of a 200-mile zone Canada and the U.S.A. have taken 98% of the total landings, contributing an average 63% and 35% respectively.

Both the Canadian and American fisheries show distinct seasonal patterns (Fig. 1a and b): major landings occur in Divs. 4VWX during the summer with a smaller peak in the winter supported by the U.S.A. Jeffrey's Ledge fishery on the spawning population in Div. 5Y (Table 3).

There are also some differences between the two countries in the gears used to harvest pollock. Traditionally the largest portion of Canadian catches have been taken by otter trawlers of tonnage class 4 and 5, with only 10% taken by gillnets, whereas in the American fishery otter trawlers take the largest proportion of the total catch but gillnets represent up to 30%.

Removals-at age for the commercial catch

Sampling of the Canadian commercial landings (Table 4) has provided age-length keys since the inception of management recommendations. Prior to 1973 seasonal coverage was incomplete, and after 1972 no foreign samples were available. Removals-at-age for 1973-1978 were taken from a previous assessment (Cleary, 1980) whilst those for 1979 and 1980 were prorated with Canadian (Table 6) and U.S.A. (Table 7) commercial samples according to their respective catches. Canadian commercial samples were also applied to catches from foreign nations. In 1980 there were no commercial gillnet samples available for the U.S.A., so this portion of the catch was prorated using data from all other gears combined from the U.S.A. commercial samples. The U.S.A. catch-at-age was supplied for ages 2 to 12+, where 12+ refers to a number of year-classes. Thus all subsequent analyses were based on ages 2 to 11 (Table 8). Commercial weights-at-age for 1973-1978 were taken from Cleary (1980); values for 1979 and 1980 were based on length-weight relationships derived from Canadian R.V. surveys and an inshore pollock tagging program (Table 9; Fig. 2a, b, c). There are noticeable differences in the age structure of the catch taken by the various gears, as is illustrated by the calculated age compositions by gear for Canadian removals in 1979 and 1980 (Table 5). The large number of age 1 fish estimated as removal by "other" gears in 1980 results from inclusion of one sample of trap caught fish. The extent to which this is representative of the trap fishery remains to be established. This estimate does not influence the following calculations of stock status.

Stock size indices

Research vessel surveys

Groundfish surveys have been conducted yearly in Div. 4VWX (in summer) by Canada since 1970 and the U.S.A. since 1964 (spring) and 1968 (fall) in Div. 4X and SA 5. In the past U.S.A. survey population estimates were based on strata 14-43, but inconsistent sampling of strata 41-43 has led to their omission to the present calculations. The U.S.A. research vessel catch rates were therefore standardized for strata 13-40 (Tables 10, 11) (S. Clark pers. comm.). Similarly Canadian research vessel surveys have provided data for strata 43-95 with highly variable catches in strata 43-52. To overcome this problem and to allow comparisons between years, two series of research vessel survey catch rates are given, one for strata 43-95, and one without 43-52 (Tables 12a & b). The large size of strata 43-52 accounts for the increase in catch rates for the series based on strata 53-95.

The U.S.A. survey data indicates that total numbers of pollock caught per tow have remained stable from 1970-1980 (Tables 10 and 11, Fig. 3). The Canadian research vessel data based on strata 53-95 only indicate stability up to 1976 and then increase up to 1980 with high values for 1977 and 1980 (8.72 and 12.44/tow respectively) (Fig. 3). Examination of these data on a set-by-set basis revealed that in both 1977 and 1980 the extremely high catch rates could be explained by high values in one or two sets. For example in 1980 the extremely high catch rates result from two sets in strata 60 and 62, whilst in 1977 there were high catches for sets in strata 80 and 85. Although these strata usually represent the large contribution to catch/tow values for any given year (Table 13) their very high values in 1977 and 1980 may be related to the inherent high variability of R.V. survey data, rather than an actual change in overall abundance.

Examination of mean catch per tow values with respect to the variance for all years indicates that the high values in 1977 and 1980 contribute a disproportionate amount of variance to the estimates. The values for the research abundance estimates are thus given for both the original data, and after removal of the sets with high values in 1977 and 1980 (Table 14).

Addition of the Canadian research vessel abundance estimates for cohort ages 2 and 3 indicates that 1968, 1971 and to a lesser extent 1974 and 1977 were large year-classes (Fig. 4). Both U.S.A. surveys point to a large year-class in 1971, whilst the spring survey shows a large 1975 year-class and the autumn a large 1976 year-class (Fig. 4). Examination of these same year-classes at ages 4 and 5 (Fig.5) indicates that the 1968, 1971 and 1975 year-classes are large in Canadian surveys, whereas the U.S.A. spring and autumn surveys point to large year-classes in 1972 and 1974, and 1971 respectively. The differences observed between the two sets of surveys need not be taken as invalidation of the survey data, but rather as an indication that there could be more than one stock of pollock involved.

In terms of catch rates the overall results indicate full recruitment to the research gear by age 5. However, from 1970-1975 the fish were recruited between ages 2 and 4.

Commercial abundance indices

Since the largest portion of the fishery is Canadian, the derivation of commercial catch rates was based on information from Canadian vessels only.

Commercial catch rates from 1972-1980 are given for otter trawlers of tonnage class 4 and 5 based on catch per unit effort for trips with 50% or more pollock in the catch (Table 15). These values were calculated from data collected during the months of June, July and August. Otter trawler catch rates were chosen because they represent the largest contribution to total landings, and the time frame was used to eliminate fluctuations in estimates due to availability changes (Fig. 1b). Whilst the Canadian catch rates remained stable from 1972-1976, there has been a general increase since then (Fig. 3). Indices for both tonnage classes show large increases in 1977 and 1979, with a decrease in 1980; although this level is still above those from 1972-1976. These results are not entirely consistent with those from the research vessel survey data, although they do indicate a similar period of good recruitment in the late 1970's.

An index of effort was obtained by dividing the total catch by the catch rate series for otter trawlers of tonnage class 4 and 5, and also for the research vessel survey catch rates.(Table 16).

Total mortality estimates

Estimates of instantaneous natural mortality for pollock on the Scotian Shelf were not available, thus a rate of 0.2 was assumed. Total mortality coefficients ($\bar{z}$) were calculated using both research vessel catch rate and commercial removals-at-age (Tables 12, 17). The commercial removals-at-age were adjusted with effort values derived from the Canadian commercial trawler fleet.

The $\bar{z}$ values calculated from commercial removals-at-age are highly variable: a three year average for TC 4 and 5 for 1978 to 1980 (Table 17) however gives values of 0.84 and 0.69 implying a F value between 0.64 and 0.49. The average $\bar{z}$ value for the same period calculated from the research vessel data is 0.59, implying an F of 0.39 (Table 18). Unfortunately the variability observed in these data makes it impossible to draw any further conclusions.

The cohort analyses were fine-tuned with age 5+ mean biomass and the catch rates of Canadian otter trawlers tonnage classes 4 and 5 (Table 15) using 3 year running averages. Age 5+ was considered to be fully recruited from preliminary runs of cohort analysis. G. M. regressions of catch rates versus biomass were calculated for 1980 F values ranging from 0.1 to 0.4 with increments of 0.05 (Table 19). The best correlations were obtained with F = 0.10, but the 1980 predicted value was much lower than the biomass calculated from cohort and the Y-intercept was negative, suggesting that at zero biomass the fleet would still catch pollock. The intercept became greater than zero at F_{80} = 0.25 for tonnage class 4, and at F_{80} = 0.30 for tonnage class 5.

The data for tonnage class 4 indicate that an F_{80} between 0.25 and 0.35 would yield a relationship predicting a 1980 $5+_{80}$ biomass very close to the value calculated by cohort analysis. However, even at F_{80} = 0.40 cohort analysis gives a 5+ biomass approximately 1.04 times the biomass predicted from the equation relating 5+ biomass to tonnage class 5 catch rates. To try to reduce this problem, the average catch rates and biomass for 1973 to 1976 were calculated and the yearly estimates for these two variables were divided by their respective average values (Table 19c). For tonnage class 4 the 1980 catch rate is 2.80 times the 1973-1976 average, while the tonnage class 5 value is 2.426 the 1973-1976 average. The results for biomasses at different F_{80} are given in Table 19c.

This indicates that F_{80} between 0.20 and 0.25 would give a biomass ratio similar to the tonnage class 4 catch ratio, whilst for tonnage class 5 the value would lie between F_{80} 0.25 and 0.30. A cohort analysis using F_{80} = 0.275 was considered the most appropriate of the series, under the criteria given above, to best represent the 1980 stock status.

Partial recruitment

The method used to adjust cohort analysis was not influenced by the partial recruitment vector for ages 2 to 4. The vector was obtained by dividing yearly age specific F's by F's at age 5, and averaging for the period 1973-1976 results were:

Age	2	3	4	5	6	7	8	9	10	11
P.R.	.046	.398	.936	1	1	1	1	1	1	1

A cohort analysis was run with this P.R. vector and F_{80} = .275: the results are presented in Table 20, Figs. 6 and 7.

Yield per recruit

A Thompson and Bell yield-per-recruit calculation was made with the partial recruitment vector and the average weights-at-age observed in the 1980 fishery (Table 9). Maximum yield-per-recruit (1.414 kg/recruit) occurred at F_{max} = 0.741, and the yield-per-recruit at $F_{0.1}$ = 0.275 is 1.284 kg/recruit, 91% of the yield at F_{max} (Table 21). The catch rate at $F_{0.1}$ is however 2.44 times that at F_{max}.

Projections

Projections to 1982 were run with the parameters given above, using the geometric mean recruitment at age 2 from 1973 to 1980 ($43,037 \times 10^3$) for the 1979 and 1980 year-classes. Fishing at $F_{0.1}$ in 1981 and 1982 would yield catches of 54,000 mt and 55,000 mt. If the 1981 catch, however does not exceed the TAC (40,000 mt), the 1982 $F_{0.1}$ catch would be 58,000 mt. The results of these projections are given in Tables 22 and 23.

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	Canada	Fed.Rep. Germany	German Dem.Rep.	Japan	Spain	USSR	United Kingdom	U.S.A.	Other	Total
1960	29470	-	-	-	763	-	-	10132	1	40386
1961	26323	-	-	-	982	-	-	10265	1	37571
1962	31721	-	-	-	-	-	-	7391	-	39112
1963	28999	126	-	-	-	906	28	6653	-	36712
1964	30007	208	-	-	-	4603	374	6006	55	41253
1965	27316	71	-	-	1361	2667	11	5303	-	36729
1966	18271	-	-	-	2384	9865	12	3791	-	34323
1967	17567	-	9	-	1779	644	1	3312	-	23317
1968	18062	-	-	-	1128	372	-	3280	7	22849
1969	15968	1188	2195	-	1515	227	-	3943	7	25043
1970	10753	3233	4710	40	532	527	-	3976	-	23771
1971	11757	633	6849	15	912	2216	-	4890	3	27275
1972	18022	475	4816	8	616	3495	4	5729	54	33219
1973	26990	1124	948	1570	3113	3092	-	6303	36	43176
1974	24975	149	2	40	1500	2348	48	8726	14	37802
1975	26548	236	96	-	709	2004	-	9318	124	39035
1976	23568	994	24	-	303	1466	-	10861	390	37606
1977	24653	308	-	1	2	268	-	13056	53	38401
1978	26801	-	-	110	-	502	-	17714	180	45307
1979	29975	/	-	19	-	1025	-	15522	70	46618
1980	35989	-	-	76	-	935	-	18274*	32	55306*

*Provisional

Table 1. Pollock Landings (MT Round Weight) by Country for Divisions 4VWX and Subareas 5 and 6, 1960-1980.

Table 2. Pollock landings by month and country for NAFO divisions 4VWX - 5 - 6

YEAR	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL[2]
							CANADA						
1972	204	993	296	930	1004	3084	3718	1192	1755	2188	2191	467	18022
1973	498	981	1521	2922	2135	4785	3239	3403	2331	2181	1955	1039	26990
1974	288	187	869	1012	1986	3730	5073	2206	2202	1634	2461	3327	24975
1975	333	230	475	2021	1524	2920	2736	3691	2312	2833	2993	4480	26548
1976	297	263	445	1498	2604	4270	3814	2327	2347	1669	1413	2621	23568
1977	1062	1748	2271	1859	1006	2202	2097	2003	2304	1333	2309	4459	24653
1978	2511	3265	1864	2070	3425	2772	2755	1228	1262	839	706	4101	26801
1979	934	1530	1539	1949	2593	4662	4854	3371	1966	1545	1528	3504	29975
1980	1466	3039	2443	1909	3400	5604	5385	3090	2219	3609	2023	1802	35989
							U.S.A.						
1972	455	318	228	229	200	394	329	294	314	488	1082	1397	5729
1973	419	313	311	406	331	418	335	302	262	573	1111	1519	6303
1974	946	558	508	650	479	388	644	570	480	661	1097	1385	8726
1975	740	721	486	594	477	924	684	743	765	598	1108	1061	9318.
1976	706	658	501	665	936	1035	985	800	1125	669	813	1305	10861
1977	1017	661	460	817	1061	1038	1350	1149	933	924	1188	1709	13056
1978	884	1065	1035	1394	1150	1347	988	1593	925	1251	2665	2620	17714
1979	1191	430	505	757	1292	1329	1259	1701	1393	1351	1872	1600	15522
1980	1006	1094	710	977	1540	1437	1605	1538	1504	1287	1961	2281	18274
							OTHERS						
1972	599	481	440	686	538	627	867	270	183	47	385	4278	9468
1973	513	1808	442	966	48	812	117	367	700	407	1996	1689	9883
1974	42	567	165	132	751	235	612	463	412	228	176	268	4101
1975	154	382	311	129	645	339	234	51	195	156	327	245	3169
1976	33	129	273	312	228	265	257	275	659	543	113	89	3177
1977	-	2	84	43	398	96	11	17	5	8	2	-	692
1978	-	-	-	9	109	172	152	105	7	92	2	8	792
1979*	-	19	3	10	705	226	101	5	48	3	1	-	1121
1980*	-	-	-	130	562	241	37	12	10	27	24	-	1043
							TOTALS						
1972	1258	1792	964	1845	1742	4105	4914	1756	2252	2723	3658	6142	33219
1973	1430	3102	2274	4294	2514	6015	3691	4072	3293	3161	5062	4247	43176
1974	1276	1312	1542	1794	3216	4353	6329	3239	3094	2523	3734	4980	37802
1975	1227	1333	1272	2744	2646	4183	3654	4485	3272	3587	4428	5786	39035
1976	1036	1050	1219	2475	3768	5571	5056	3402	4131	2881	2339	4015	37606
1977	2079	2411	2815	2719	2465	3336	3458	3169	3242	2265	3499	6168	38401
1978	3395	4330	2899	3473	4684	4291	3895	2926	2194	2182	3373	6732	45307
1979*	2125	1979	2047	2716	4590	6217	6214	5077	3407	2899	3401	5104	46618
1980*	2472	4133	3153	3016	5502	7282	7027	4640	3733	4923	4008	4083	55306

*Provisional

[2]Includes NK months of the year

Table 3. Pollock landings (T, round fresh) for divisions 4VWX, subarea 5, and statistical area 6, 1960-80

YEAR	4Vn	4Vs	4W	4X	Total 4VWX	5Y	5Ze	5Zw	Total 5Z	5Ac	Total SA 5	5Ab	Total
1960	691	811	8354	20132	29988	6545	-	-	3834	18	10397	-	40385
1961	811	1053	13167	14321	29352	5017	-	-	3177	25	8219	-	37571
1962	554	738	12045	19624	32961	2560	-	-	3576	15	6151	-	39112
1963	400	274	9152	20645	30471	2168	-	-	3947	10	6125	116	36712
1964	337	137	12488	19283	32245	1754	-	-	7250	-	9004	4	41253
1965	147	1058	13134	13390	27729	1933	-	-	7065	-	8998	2	36729
1966	226	562	11040	12648	24476	953	-	-	8846	-	9799	48	34323
1967	147	510	5836	8290	14783	1728	-	-	6790	14	8532	2	23319
1968	256	757	5954	10656	17623	1416	3724	82	3806	-	5222	4	22849
1969	91	209	3938	10983	15221	4635	5025	162	5187	-	9822	-	25043
1970	130	519	2952	8194	11795	6281	5157	123	5280	-	11561	415	23771
1971	214	317	1802	9739	12072	7016	7096	142	7238	58	14312	891	27275
1972	102	495	3419	16190	20206	6419	6519	51	6570	-	12989	24	33219
1973	170	834	5871	23225	30100	5202	6235	1618	7853	-	13055	21	43176
1974	68	239	4740	20362	25409	6106	6233	5	6238	-	12344	49	37802
1975	179	620	5697	18668	25164	6015	7848	3	7851	-	13866	5	39035
1976	52	1050	3424	19700	24226	6441	6915	11	6929	12	13379	3	37608
1977	166	1181	6082	14700	22129	8278	7846	79	7925	36	16239	34	38402
1978	98	2833	4910	15161	23002	12238	9943	17	9960	91	22289	16	45307
1979	356	4501	4987	18343	28187	9838	8356	11	8367	218	18423	8	46618
1980[a]	486	3306	6577	20363	30732	11388	6802	18	11898	245	23531	-	55306*

a provisional
* includes foreign landings all areas

TABLE 4. Canadian commercial samples available for pollock in NAFO Div. 4V, 4W, 4X and Subarea 5, since 1948 (the first number represents the number of fish aged and the second number is the number of fish measured). Gear mnemonics are those used by NAFO.

4V

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1949												
LDV	-	0/100	-	-	-	-	-	-	-	-	-	-
1962												
OTB-1	-	-	-	-	40/200	-	-	-	-	-	-	-
FIX	-	-	-	-	-	-	50/179	-	-	-	-	-
1976												
OTB-2	-	-	-	-	-	-	-	-	29/269	-	-	-
1977												
OTB-2	-	-	-	-	-	-	-	30/298	28/200	-	-	-
1978												
OTB-2	-	-	41/1226	-	104/931	-	38/314	-	-	35/300	-	-
1979												
OTB-1	-	-	-	-	-	-	54/549	-	-	-	-	-
OTB-2	-	-	32/150	-	-	27/354	167/1598	109/1062	-	-	-	-
1980												
OTB-1	-	-	-	60/356	-	-	-	-	-	-	-	-
OTB-2	-	21/181	-	-	-	-	-	-	-	48/262	-	-

5ZE, 5Y

1967												
OTB-1	-	0/100	-	-	-	-	-	-	-	-	-	-
1971												
OTB-2	-	-	-	-	-	-	-	-	-	34/259	-	-
1974												
OTB-2	-		-	-	-	-	-	-	-	59/606	-	-
1975												
OTB-2	-		-	-	-	-	-	48/329	-	92/522	52/323	-
OTB-1	-		-	32/115	-	-	30/229	-	-	42/182	-	-
1976												
OTB-2	-		-	-	-	78/544	-	31/325	-	-	-	-
1977												
OTB-2	39/205	123/655	-	-	-	-	38/219	-	-	-	-	-

(Cont'd)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1978												
OTB-2	-	154/1375	-	-	-	26/192	-	-	-	-	-	-
OTB-1	-	-	-	-	-	-	-	-	-	22/266	-	-
1979												
OTB-2	-	-	-	-	-	-	33/200	-	37/266	-	-	-
OTB-1	-	-	-	-	-	-	23/187	-	-	-	-	-
1980												
OTB-2	-	26/269	-	-	-	27/216	21/284	-	-	108/713	-	-
OTB-1	-	-	-	-	52/400	-	-	35/257	30/168	36/186	-	-

4W

1948												
OTB-1	-	0/100	0/100	0/100	-	-	-	-	-	-	-	-
1949												
OTB-1	-	0/200	-	-	-	-	-	-	-	-	-	-
1950												
OTB-1	-	0/100	0/100	-	-	-	-	-	-	-	-	-
1961												
OTB-1	-	-	-	-	-	-	-	-	-	-	0/107	-
1962												
OTB-1	-	-	58/116	-	-	-	-	-	-	-	131/22	70/107
1963												
OTB-1	-	-	-	-	-	-	-	-	-	-	0/292	0/204
1964												
OTB-1	-	-	-	-	0/546	-	-	-	-	-	-	-
1965												
OTB-1	-	-	-	-	46/218	-	-	-	-	0/312	-	-
1966												
OTB-1	-	-	-	-	-	-	-	-	-	-	0/279	-
1967												
OTB-2	-	-	-	-	-	-	0/262	0/218	-	0/179	-	-
1968												
OTB-2	-	-	-	-	-	0/265	-	-	-	-	-	-

(Cont'd)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1969												
OTB-2	-	0/202	-	-	-	-	-	-	-	-	-	-
1970												
OTB-2	0/241	-	-	-	-	-	-	-	-	-	-	-
OTB-1	0/559	-	-	55/166	-	-	-	-	-	-	-	-
1973												
OTB-1	-	-	-	-	-	-	-	-	-	71/470	151/843	54/251
1974												
OTB-1	-	-	-	-	-	50/217	-	48/309	-	-	-	38/207
1975												
OTB-2	-	-	-	44/243	-	-	-	-	-	-	40/129	27/247
OTB-1	34/209	-	-	-	43/311	-	-	-	-	-	-	-
1976												
OTB-2	-	-	-	58/285	-	-	-	-	-	-	-	47/217
OTB-1	-	-	-	-	-	-	51/200	-	40/270	-	-	-
1977												
OTB-2	-	-	44/44	-	-	-	-	49/303	38/200	-	43/330	47/215
OTB-1	-	47/200	-	-	-	59/300	47/299	103/597	102/559	48/300	47/304	56/297
1978												
OTB-2	34/203	38/305	23/279	37/319	-	-	-	-	-	-	-	-
OTB-1	45/241	-	85/454	-	-	44/214	-	-	-	-	-	-
FIX	-	-	-	-	-	46/1059	-	-	-	-	-	-
1979												
OTB-2	-	-	-	-	36/421	95/1012	27/308	-	-	-	-	-
OTB-1	-	-	-	-	28/219	28/269	71/485	28/306	-	-	-	23/100
FIX	-	-	-	-	-	41/271	-	-	-	-	-	-
1980												
OTB-2	-	71/529	-	-	-	-	-	-	-	-	93/779	40/198
OTB-1	-	92/711	-	-	-	-	27/167	-	-	-	-	-
FIX	-	-	-	-	22/219	-	-	-	-	-	-	-

(Cont'd)

Year	Jan.	Feb.	Mar.	Apr.	May	4X June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1962												
OTB-1	-	-	-	-	98/182	-	-	-	-	32/114	-	-
1963												
OTB-1	-	-	-	-	-	0/485	-	-	0/150	-	0/126	-
1964												
OTB-1	-	-	-	-	-	-	-	-	-	0/279	-	-
1965												
OTB-1	-	-	-	-	-	-	-	-	-	0/147	-	-
1966												
OTB-1	-	-	-	-	-	0/96	-	-	-	-	-	-
1967												
OTB-1	-	-	-	-	-	-	0/152	-	-	-	-	-
1968												
OTB-1	-	-	-	0/392	-	-	-	0/230	-	0/247	-	-
1969												
OTB-1	-	-	-	-	-	-	0/183	-	-	0/270	0/302	-
1970												
OTB-2	0/300	-	-	-	-	39/145	-	-	-	30/132	-	-
OTB-1	0/306	-	-	-	-	35/141	64/197	-	34/185	-	-	-
1971												
OTB-2	-	-	-	-	-	-	-	25/60	-	-	-	-
OTB-1	-	-	-	-	179/418	34/139	33/183	26/53	-	-	-	-
1972												
OTB-2	-	-	-	-	-	37/239	-	-	-	-	23/237	-
OTB-1	-	-	-	33/112	26/119	-	-	-	-	26/197	63/360	-
1973												
OTB-2	-	-	-	-	30/153	-	-	-	-	35/192	-	-
OTB-1	-	44/152	83/432	-	40/156	80/418	-	0/232	38/212	-	26/124	-
1974												
OTB-2	-	-	-	0/69	36/216	-	-	-	91/456	38/292	-	76/532
OTB-1	-	-	42/189	111/625	91/370	49/245	59/208	49/230	27/201	25/485	23/262	-
1975												
GN	-	-	-	-	-	-	-	-	32/224	-	-	-
OTB-2	-	-	-	41/239	37/260	80/289	-	36/159	-	-	-	-
OTB-1	66/518	-	-	61/333	70/339	115/575	52/200	24/204	-	-	-	-

(Cont'd)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1976												
GN	-	-	-	-	-	-	28/247	35/198	-	-	-	-
OTB-2	45/231	-	-	-	28/248	115/919	63/570	-	73/404	-	44/204	-
OTB-1	-	47/364	32/211	74/339	-	33/228	28/28	47/200	-	-	62/430	40/177
1977												
GN	-	-	-	-	30/256	-	-	-	-	-	-	-
OTB-2	-	79/496	286/1478	75/473	-	-	-	-	49/400	-	43/205	-
OTB-1	42/240	109/514	74/554	75/419	-	-	-	79/494	26/170	76/533	-	-
1978												
GN	-	-	-	-	-	55/323	-	28/183	25/195	25/61	-	-
OTB-2	-	-	92/457	66/481	32/232	37/303	56/406	-	-	-	-	27/245
OTB-1	-	65/358	35/268	-	104/884	-	70/472	-	-	-	-	-
1979												
OTB-2	-	113/830	-	-	-	79/639	24/314	-	-	-	-	-
OTB-1	-	-	26/141	22/208	35/252	-	-	-	-	-	-	-
GN	-	-	-	-	31/251	-	28/262	-	-	-	-	-
LHP	-	-	-	-	-	-	-	37/214	-	-	-	-
1980												
OTB-2	109/832	32/341	70/519	28/299	-	32/217	34/191	37/269	-	-	114/628	43/201
OTB-1	-	35/258	-	28/210	86/661	28/200	72/554	-	-	-	39/164	-
GN	-	-	-	-	-	27/236	-	-	-	-	-	-
						4V - 4X						
1975												
OTB	-	-	-	-	-	-	-	-	-	38/211	-	-
						4V - 4W						
1976												
OTB-2	-	-	-	-	-	-	-	-	-	-	81/549	-
1978												
OTB-1	-	-	-	-	-	-	43/261	-	-	-	-	-
1979												
OTB-1	-	-	-	-	-	-	-	53/624	-	-	-	-
OTB-2	-	-	-	67/703	44/354	-	35/311	73/588	-	-	-	-

(Cont'd)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.
1980 OTB-2	-	-	-	-	-	35/386	-	-	-	-	-	-
						4X - 5Z						
1973 OTB	-	-	-	-	-	-	-	-	-	66/493	-	-
1974 OTB-2	-	-	-	-	-	-	-	-	-	-	-	-
OTB-1	-	-	-	-	-	-	-	-	53/736	30/378	-	-
1975 OTB-2	-	-	-	-	-	-	-	27/362	-	-	-	36/225
1976 OTB-2	-	-	-	-	-	-	-	38/331	-	-	-	-
1977 OTB-2	-	152/853	47/282	-	-	76/499	-	-	-	-	-	41/268
1978 OTB-2	-	67/637	50/628	-	36/303	21/311	-	-	-	-	-	-
OTB-1	-	-	-	-	-	35/302	24/393	-	-	-	-	-
1979 OTB-2	-	-	-	-	-	36/350	-	-	-	-	-	-
1980 OTB-2	-	-	-	-	-	-	-	-	-	-	-	46/313
						4W - 5Z						
1976 OTB	-	-	-	-	-	-	-	-	-	41/289	-	-
1978 OTB-2	-	82/630	-	-	-	-	-	-	-	-	-	-
1980 OTB-2	-	-	-	-	-	-	-	-	-	43/286	-	-
						4W - 4X						
1974 OTB-1	-	-	-	40/258	-	-	-	-	-	-	-	-

(Cont'd)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1975												
OTB-2	-	-	-	-	-	-	-	-	-	-	-	-
OTB-1	-	-	-	79/472	-	-	-	-	35/201	-	-	44/325
1976												
OTB-2	-	-	-	-	-	37/218	-	-	-	40-207	-	-
OTB-1	-	-	-	-	-	41/212	-	-	-	-	-	-
1977												
OTB-2	-	-	96/499	46/200	-	-	-	-	-	-	-	48/301
OTB-1	-	-	-	42/300	-	-	-	-	-	36/300	41/261	-
1978												
OTB-2	-	-	70/263	43/314	-	68/595	-	-	-	-	-	-
1980												
OTB-2	-	-	39/377	35/279	-	-	-	-	-	-	-	-
						4W - 4X -5Z						
1975												
OTB-1	-	-	-	-	-	-	-	-	-	80/568	-	-
1977												
OTB-2	-	-	-	-	-	-	-	-	-	-	-	45/254
1978												
OTB-2	85/566	38/300	34/662	-	-	-	-	-	-	-	-	-
1979												
OTB-2	-	-	-	-	-	-	-	35/287	-	-	-	-
1980												
OTB-1	-	-	-	-	-	-	-	-	-	-	-	70/400
						4V - 4W - 4X						
1978												
OTB-2	-	-	-	-	-	-	27/326	-	-	-	-	-
OTB-1	-	-	-	-	-	-	42/273	-	-	-	-	-
1980												
OTB-2	-	-	-	-	-	-	25/307	-	-	-	-	-
						4V - 4X - 5Z						
1978												
OTB-2	-	-	-	-	48/307	-	-	-	-	-	-	-

Table 5 Removals-at-age (x 10^{-3}) for Canadian commercial landings from ICNAF Div. 4VWX-5 and 6 by gear type for 1979 and 1980.

AGE	OTB-1, 2 TC 1,2,3	OTB-1,2 TC 4	OTB-1,2 TC 5	GN/GNS GND	LL/LHP LTL/LLS	OTHERS	TOTAL
			Year - 1979				
1	-	-	-	-	-	3	3
2	15	2	-	-	4	5	26
3	1150	36	277	-	454	177	2094
4	755	648	2692	64	282	503	4944
5	578	669	1466	260	44	7	3024
6	120	308	587	572	66	-	1653
7	41	57	177	151	12	-	438
8	-	11	35	76	12	-	134
9	-	12	2	41	-	-	55
10	-	5	-	1	16	-	22
11	-	4	-	6	-	-	10
12	-	4	-	-	-	-	4
Σ	2659	1756	5236	1171	890	695	12407
			Year - 1980				
1	-	-	-	-	-	3302	3302
2	20	15	137	-	8	24	204
3	35	34	697	-	931	24	1721
4	336	125	2418	137	577	81	3674
5	465	394	3846	538	90	1	5334
6	265	313	1827	234	134	-	2773
7	109	119	355	55	25	-	663
8	45	46	26	-	34	-	151
9	26	5	68	-	7	-	106
10	9	4	20	-	-	-	33
11	5	2	10	-	-	-	17
12	4	1	6	-	-	-	11
Σ	1319	1058	9410	964	1806	3432	15489

Table 6. Removals-at-age for Canada and other nations, except the U.S.A., for catches of pollock in NAFO area 4VWX - 5 and 6 for 1973-1980.

	1973	1974	1975	1976	1977	1978	1979	1980
2	197	303	231	392	150	104	31	176
3	1017	4417	2290	2149	2233	2297	2269	1278
4	9770	1808	5832	2554	3029	4136	4575	3016
5	3881	2425	1570	3240	1750	3016	2883	4815
6	894	1147	1397	860	2111	1193	1823	2531
7	689	397	432	638	775	1135	474	661
8	289	318	96	155	348	311	163	161
9	431	84	34	18	75	96	77	91
10	406	92	42	25	21	18	27	21
11	79	89	30	17	24	27	13	41

Table 7. Removals-at-age for pollock in NAFO Areas 4VWX-5 and 6, 1973-1980 for USA

AGE	1973	1974	1975	1976	1977	1978	1979	1980
1	-	-	-	-	-	-	9.3	45.4
2	1659	314	141	122	20.2	91.6	202.4	312.9
3	578	2864	1056	803	292.9	725.7	1359.0	672.1
4	1218	1091	2602	1029	943.1	549.7	1773.4	2701.0
5	460	1200	320	1212	681.0	648.9	1039.0	1136.1
6	155	180	258	373	825.9	631.0	500.1	569.2
7	106	115	123	323	326.0	936.1	242.5	452.7
8	74	96	42	104	261.1	349.4	284.9	250.3
9	26	28	21	11	99.3	270.2	113.5	240.3
10	15	32	28	7	62.3	133.8	46.6	118.8
11	-	14	17	17	19.8	84.3	24.9	67.1
12+	-	21	10	18	195.2	211.3	112.2	76.4

Table 8. Removals-at-age for total catches of pollock in NAFO areas 4VWX-5 and 6 from 1973-1980.

	1973	1974	1975	1976	1977	1978	1979	1980
2	1856	617	372	514	170	196	234	489
3	1595	7281	3346	2952	2526	3023	3628	1950
4	10988	2899	8434	3583	3972	4686	6349	5718
5	4341	3625	1890	4452	2431	3665	3922	5951
6	1049	1327	1655	1233	2937	1824	2323	3100
7	795	512	555	961	1101	2071	717	1114
8	363	414	138	259	609	660	448	411
9	457	112	55	29	174	366	191	331
10	421	124	70	32	83	152	74	140
11	79	103	47	34	44	111	38	78

Table 9. Commercial weight-at-age (kg) for pollock caught by trawlers in ICNAF area 4VWX-5

AGE	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	-	-	-	-	-	-	-	-	0.10
2	1.10	0.78	0.81	0.89	0.81	0.93	0.86	0.91	1.22
3	2.18	1.58	1.44	1.47	1.55	1.10	1.07	1.39	1.87
4	3.39	2.38	2.18	2.10	2.20	1.55	1.57	1.95	2.27
5	4.36	3.12	3.07	2.97	2.97	2.45	2.24	2.86	3.07
6	5.17	3.67	4.10	3.95	3.76	3.35	3.32	3.72	3.34
7	5.94	4.42	5.10	5.00	4.51	4.34	4.13	4.46	4.14
8	6.37	4.96	6.11	6.24	5.18	5.63	5.44	6.33	5.92
9	6.76	5.70	6.68	7.07	6.14	6.38	6.52	6.00	6.24
10	7.39	5.64	7.27	7.29	7.64	7.22	7.08	7.34	7.87
11	6.67	7.40	8.01	7.83	7.66	8.32	7.97	8.04	8.48
12	7.65	7.59	8.65	8.88	7.26	9.11	8.76	8.84	12.78

Table 10. Stratified Mean Catch per tow at age (nos.) for pollock (41 Yankee Trawl) spring survey cruises in Strata 13-40.

U.S.A. SPRING SURVEY — STRATA 13-40 — 41 YANKEE TRAWL

AGE	1973	1974	1975	1976	1977	1978	1979	1980
0	-	-	-	-	-	-	-	-
1	0.01	0.01	0.01	0.08	0.14	0.00	0.10	0.15
2	2.80	0.10	0.33	0.11	0.38	0.22	0.05	0.15
3	0.51	0.53	0.20	0.14	0.23	0.42	0.07	0.09
4	0.15	0.14	0.34	0.15	0.06	0.65	0.08	0.28
5	0.14	0.08	0.08	0.24	0.16	0.63	0.15	0.25
6	0.04	0.16	0.09	0.13	0.32	0.15	0.14	0.20
7	0.03	0.07	0.10	0.15	0.13	0.11	0.08	0.23
8	0.10	0,03	0.08	0.17	0.11	0.08	0.16	0.08
9	0.04	0.00	0.05	0.11	0.02	0.07	0.08	0.04
10	0.09	0.01	0.06	0.03	0.02	0.05	0.03	0.02
11	0.02	0.10	0.02	0.04	0.01	0.04	0.03	0.00
12+	0.09	0.16	0.29	0.24	0.04	0.07	0.08	0.05
Σ	4.00	1.39	1.65	1.59	1.63	2.47	1.06	1.51

Table 11. Stratified mean catch per tow at age (nos.) for pollock (36 Yankee Trawl) autumn survey cruises in Strata 13-40.

U.S.A. AUTUMN SURVEY STRATA 13-40 36 YANKEE TRAWL

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0.01	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
1	0.13	0.11	0.38	0.03	0.00	0.22	0.03	0.06	0.03	0.01	0.13
2	0.08	0.38	0.27	0.71	0.08	0.06	0.03	0.17	0.19	0.02	0.01
3	0.01	0.16	0.20	0.12	0.28	0.03	0.15	0.24	0.04	0.26	0.01
4	0.09	0.02	0.08	0.17	0.20	0.11	0.55	0.29	0.04	0.33	0.05
5	0.08	0.06	0.07	0.11	0.11	0.07	1.63	0.42	0.09	0.19	0.11
6	0.08	0.09	0.08	0.11	0.08	0.04	0.50	0.38	0.09	0.13	0.06
7	0.04	0.04	0.07	0.09	0.09	0.09	0.31	0.22	0.15	0.08	0.07
8	0.02	0.08	0.05	0.07	0.01	0.01	0.14	0.11	0.08	0.09	0.13
9	0.01	0.03	0.04	0.00	0.02	0.01	0.05	0.09	0.06	0.05	0.08
10	0.02	0.01	0.03	0.12	0.00	0.01	0.01	0.02	0.04	0.04	0.06
11	0.01	0.01	0.03	0.02	0.02	0.01	0.01	0.02	0.03	0.01	0.04
12+	0.07	0.09	0.10	0.10	0.02	0.03	0.29	0.12	0.12	0.06	0.07
Σ	0.63	1.09	1.41	1.64	0.90	0.70	3.69	2.14	0.98	1.27	0.82

Table 12a. Stratified mean catch per tow at age (number) for pollock in Canadian summer bottom trawl surveys in Divisions 4VWX for 1971-1979 in strata 43-95.

ge	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	1.9164	.7748	.1034	.4281	.0438	.0080	.0347	.2783	.0040	-	.6103
3	.4709	.5777	.2028	.3991	1.0096	.0193	.2136	.8357	.1841	.1180	.7232
4	.2872	.1774	1.3354	1.2369	.2528	.3513	.6121	1.0563	.6731	.7094	2.0560
5	.2099	.0429	.3968	.4334	.3318	.2993	1.0774	2.1758	.9897	.8188	3.6484
6	.2054	.0199	.1232	.0956	.1797	.3933	.2597	1.5281	.3645	.6079	1.2668
7	.1710	.0341	.0358	.0329	.2037	.0659	.4280	.2159	.3333	.2502	.7637
8	.1034	.0119	.0636	.0347	.1182	.0976	.1551	.3829	.1043	.1630	.2892
9	.0398	.0080	.0549	.0546	.0904	.0310	.0437	.1290	.0458	.0119	.1102
0	-	.0239	.0279	.0040	.0561	.0040	.0477	.0676	.0023	.0398	.0665
1	.0464	-	.0119	.0278	.1342	.0080	.0199	.0358	-	-	-
2	.0119	-	.0080	.0119	.0481	-	.0199	.0159	.0159	-	-
2+	-	-	.0199	-	-	-	.0278	-	.0119	-	-
K	.0080	-	.0119	-	-	-	.0080	.0040	.0407	.0461	.0055

Table 12b. Stratified mean catch per tow at age (number) and total mortality coefficient (Z) calculated for pollock in Division 4VWX, 1970-1980 in strata 53-95.

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	2.4963	1.0062	.1347	.5425	.0570	.0104	.0452	.3625	.0052	-	.7950
3	.6134	.7494	.2641	.5199	1.3151	.0251	.2782	1.0522	.2398	.1494	.9420
4	.3741	.2311	1.7394	1.6112	.3293	.4333	.7943	1.3699	.8768	.8696	2.6781
5	.2734	.0559	.5169	.5645	.4322	.3898	1.4035	2.8341	1.2831	.9849	4.7523
6	.2675	.0259	.1605	.0777	.2341	.5123	.3382	1.9905	.4718	.7495	1.6501
7	.2227	.0414	.0466	.0311	.2653	.0859	.5575	.2913	.4292	.3300	.9948
8	.1347	.0155	.0829	.0570	.1540	.1271	.2020	.4988	.1359	.2123	.3767
9	.0518	.0104	.0715	.0711	.1177	.0404	.0570	.1681	.0596	.0155	.1435
10	-	.0311	.0363	.0052	.0731	.0052	.0621	.0880	-	.0518	.0866
11	.0604	-	.0155	.0363	.1748	.0104	.0259	.0466	-	-	-
12	.0155	-	.0104	.0155	.0627	-	.0259	.0207	.0207	-	-
12+	-	-	.0259	-	-	-	.0363	-	.0155	-	-
UK	.0104	-	.0155	-	-	-	.0104	.0052	.0530	.0600	.0071
Z 5+/6+		2.096	-0.855	1.152	-0.249	0.557	-0.038	-0.156	1.666	0.560	-0.327
Z 6+/7+		2.014	-0.750	0.648	-1.113	1.161	-0.113	0.119	1.562	0.586	-0.164

Table 13. Rank of stratum based on the number of fish landed for [illegible] 1970-1980

STRATUM	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
53											
54											
55											
56											
57											
58											
59											
60	1					4			2		1
61						1					
62					2	3					2
63											
64									4		
65		1			1						
66											
70		4		2			1	4	1		
71											
72		2									4
73											
74											
75											
76				4	3	2		3			
77											
78											
80								2			
81		3		3							
82										3	
83			4								
84							2			4	
85	2		1	1				1		2	3
90	3						4		3		
91			2							1	
92			3		4		3				
93	4										
94											
95											

Table 14. Catch-at-age (estimated total population numbers x 10^{-3}) from the Canadian summer bottom trawl surveys 1970-1980.

A = original values

A.

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2	8879	3579	479	1929	203	37	161	1290	18	1747	2828
3	2182	2666	939	1849	4677	89	989	3743	852	531	3351
4	1330	822	6187	5731	1171	1541	2825	4873	3118	3093	9525
5	972	199	1838	2007	1537	1386	4992	10081	4563	3503	16902
6	951	92	570	276	832	1822	1202	7080	1678	2665	5869
7	792	147	165	110	943	305	1983	1001	1523	1173	3536
8	479	55	294	202	547	452	718	1775	483	755	1338
9	184	36	254	252	418	142	202	598	211	55	509
10	159	110	129	18	260	18	220	313	173	184	306
11	214	187	55	129	621	36	92	166	187	187	188
12	55	87	36	55	223	87	92	74	73	87	88

B.

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2								787			146
3								4037			232
4								2901			815
5								3094			2512
6								3760			2199
7								947			1690
8								1820			794
9								862			328
10								527			180
11								231			188
12								157			88

B = adjusted values 1977, 1980

Table 15. Pollock research and commercial catch per unit of effort in ICNAF Div. 4VWX-5 and 6.

RESEARCH CRUISES	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Canadian summer bottom trawl survey ($No\cdot Tow^{-1}$)	4.53	2.17	3.14	3.53	3.22	1.64	3.84	8.72	3.59	3.42	12.44
U.S.A. autumn bottom trawl survey ($No\cdot Tow^{-1}$)	0.63	1.09	1.41	1.64	0.90	0.70	3.69	2.14	0.98	1.27	0.82
U.S.A. spring bottom trawl survey ($No\cdot Tow^{-1}$)	-	-	-	4.00	1.39	1.65	1.59	1.63	2.47	1.06	1.51
COMMERCIAL											
Canadian otter trawlers 500-999.9 G.T. C.P.U.E. for $\geq$ 50% of Pollock in total catch ($mt\cdot hr^{-1}$)	-	-	0.78	0.67	0.67	0.69	0.55	1.05	0.85	2.32	1.07
Canadian otter trawlers 150-499.9 G.R.T. C.P.U.E. for $\geq$ 50% of pollock in total catch ($mt\cdot hr^{-1}$)	-	-	0.52	0.70	0.51	0.48	0.47	0.50	0.25	1.73	1.00

Table 16 . Effort calculated with total landings divided by catch rates for Pollock.

RESEARCH CRUISES	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Canadian summer bottom trawl survey	5,246	12,587	10,593	12,224	11,721	23,529	9,803	4,405	12,638	13,619	4,446
American autumn bottom trawl survey	37,731	25,023	23,559	26,327	42,002	55,764	10,192	17,944	46,231	36,707	67,446
American spring bottom trawl survey	-	-	-	10,794	27,196	23,657	23,653	23,559	18,343	43,979	36,626
COMMERCIAL											
Canadian otter trawlers 500-999 G.R.T. ≥ 50% of pollock in total catch	-	-	42,588	64,442	56,421	56,572	68,378	36,572	53,302	20,094	51,688
Canadian otter trawlers 150-499.9 G.R.T. ≥ 50% pollock in total catch	-	-	63,882	61,680	74,121	86,744	80,017	76,802	181,228	26,946	55,306

Table 17. Total mortality coefficients (Z) for pollock from total commercial catch-at-age data using efforts estimated from Canadian commercial otter trawl (TC4 = 150-499.9 GRT, TC5 = 500-999.9)

	1973	1974	1975	1976	1977	1978	1979	1980
Numbers								
6-11	3164	2591	2518	2545	4715	4672	3791	5174
7-12	-	1304	887	1337	3710	2933	1580	2150
TC5 Effort	64442	56421	56572	68378	36572	53302	20094	51688
Numbers/Effort								
6-11	0.0491	0.059	0.044	0.0372	0.1289	0.088	0.1887	0.1001
7-12	-	0.0231	0.017	0.0196	0.1014	0.055	0.0786	0.0416
$\bar{Z}a$	0.75	1.24	0.81	-1.00	0.85	0.11	1.51	

$$\bar{Z}\ 1977\text{-}1980 = \ln\left(\frac{.4056}{.1752}\right) = 0.84$$

TC 4 Effort	61680	74121	86744	80017	76802	181228	26946	55306
Numbers/Effort								
6-11	0.0513	0.0350	0.0290	0.0318	0.0614	0.0258	0.1407	0.0936
7-12	-	0.0176	0.0102	0.0153	0.0483	0.0162	0.0586	0.0389
$\bar{Z}a$	1.07	1.23	0.63	-0.42	1.33	-0.82	1.29	

$$\bar{Z}\ 1977\text{-}1980 = \ln\left(\frac{0.2279}{0.1137}\right) = 0.69$$

Table 18. Total mortality coefficients (Z) for pollock based on effort series and estimates of population abundance from Canadian research vessel surveys for 1977-1980.

Numbers	YEAR			
	1977	1978	1979	1980
6-11	10,933	4,255	5,019	-
7-12	-	2,650	2,441	6,065
Z_a		1.4172	0.557	-0.1893

$$Z_{1977\text{-}1980} = \ln\left(\frac{20207}{11156}\right) = 0.59$$

Table 19a. Results of cohort analysis runs fine tuning[1] with TC4 catch rates for Pollock.

		F = 0.10		F = 0.15		F = 0.20		F = 0.25		F = 0.30		F = 0.35		F = 0.40	
	CATCH RATE	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED
1973	.577	50925	109389	47649	87125	46005	75956	45017	69223	44357	64706	43886	61450	43533	58973
1974	.560	64735	103649	58553	83562	55455	73476	53594	67390	52354	63299	51458	60343	50805	58087
1975	.340	75255	29372	65468	37441	60572	41381	57635	43660	55679	45092	54284	46022	53240	46613
1976	.480	108128	76639	91777	66790	83597	61805	78691	58761	75423	56679	73092	55135	71348	53915
1977	.410	110497	53006	88946	52115	78155	51593	71677	51210	67359	50885	64277	50579	61968	50264
1978	.830	136647	194807	102405	140165	85241	112865	74921	96513	68030	85645	63103	77919	59407	72168
1979	.99	251696	248826	176192	173707	138435	136207	115782	113771	100684	98886	89906	88335	81829	80512
1980	1.37	394929	377122	263286	253371	197464	191643	157971	154760	131643	130335	112837	113071	98732	100330
Intercept			-85419		-33837		-8220		6986		16954		23889		28881
Coefficient			337621		209641		145886		107864		82760		65096		52152
r			.922		.913		.901		.885		.863		.834		.795

[1] fine tuning was done between 5+ mean biomass and CPUE (mt/hour) of Canadian OTB TC4 for June - July - August for trips with pollock representing 50% or more of the total catch (from Table 15).

Table 19 b. Results of cohort analysis runs fine tuning[1] with TC5 catch rates for Pollock.

		F = 0.10		F = 0.15		F = 0.20		F = 0.25		F = 0.30		F = 0.35		F = 0.40	
	CATCH RATE	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED	COHORT	PREDICTED
1973	.706	50925	62555	47649	58045	46005	55719	45017	54261	44357	53226	43886	52420	43533	51739
1974	.680	64735	55222	58553	53492	55455	52550	53594	51918	52354	51429	51468	51006	50805	50606
1975	.637	75255	43095	65468	45961	60572	47310	57635	48044	55679	48456	54284	48668	53240	48733
1976	.763	108128	78360	91777	68026	83597	62665	78691	59397	75423	57167	73092	55519	71348	54222
1977	.817	110497	93860	88946	77483	78155	69246	71677	64262	67359	60900	64277	58456	61968	56575
1978	1.40	136647	258280	102405	179577	85241	140292	74921	116792	68030	101204	63103	90157	54907	81973
1979	1.41	251696	261101	176192	181329	138435	141510	115782	117693	100684	101895	89906	90701	81829	82408
1980	1.69	394929	340068	263286	230362	197464	175632	157971	142921	131643	121252	112837	105927	98732	94606
Intercept			-136555		-65590		-30316		-9351		4419		14030		20982
Coefficient			282025		175119		121863		90102		69132		54377		43564
r			.894		.889		.980		.868		.852		.829		.796

[1] fine tuning was done between 5+ mean biomass and CPUE (mt/hour) of Canadian OTB TC5 for June - July - August for trips in which pollock was representing 50% or more of the total catch (from Table 15).

Table 19c. Pollock standardized catch rates and biomasses (standardized to 1973-1976 averages) for different F's in 1980.

YEAR	TC 4 Standard	TC 5 Standard	F=0.1	F=0.15	F=0.20	F=0.25	F=0.30	F=0.35	F=0.40
1973	1.179	1.014	.760	.805	.831	.849	.861	.870	.877
1974	1.145	.976	.889	.912	.925	.933	.940	.944	.948
1975	.695	.915	.965	.950	.941	.935	.930	.927	.925
1976	.981	1.095	1.385	1.334	1.303	1.283	1.269	1.258	1.250
1977	.838	1.173	1.424	1.310	1.243	1.199	1.168	1.145	1.127
1978	1.696	2.010	1.752	1.514	1.373	1.281	1.216	1.167	1.130
1979	2.024	2.024	3.057	2.436	2.071	1.830	1.659	1.533	1.435
1980	2.800	2.426	4.77	3.625	2.950	2.505	2.191	1.956	1.776

Table 20. Results of cohort analysis using the partial recruitment multipliers of 0.046, 0.398 and 0.936 for ages 2 to 4, and 1 for ages 5+, F_{80} = 0.275.

POLLOCK POPULATION NUMBERS

	1973	1974	1975	1976	1977	1978	1979	1980
2	55968	28873	27377	51113	14288	48407	15553	43137
3	19048	44144	22081	20873	41000	11464	37311	33156
4	26013	14322	33551	16758	15441	31736	10316	29479
5	9488	11353	6107	16545	8761	11780	21629	7154
6	3252	3840	6015	3746	9554	5734	3755	14183
7	1920	1714	1944	3427	3589	6139	3082	5080
8	913	853	940	1099	1936	1942	2341	1844
9	974	419	323	644	657	1034	992	1511
10	804	384	242	212	501	280	515	440
11	195	277	202	135	147	333	174	355
2+	118797	106194	109292	125477	104208	129870	141093	142223
3+	62829	77311	71407	74364	89840	113464	112553	98191
4+	43557	33167	48326	53491	48853	90999	77740	78493
5+	17547	18840	18773	37821	26116	59404	37521	50817

POLLOCK POPULATION BIOMASS

	1973	1974	1975	1976	1977	1978	1979	1980
2	43635	23387	33709	41402	29769	39910	23239	35606
3	30434	63567	33929	47543	65521	56137	54657	48730
4	61904	31233	62063	34913	34785	73405	24027	62032
5	29604	34854	27048	49199	23889	33107	61858	33455
6	11936	15746	23759	21605	31939	19202	32478	47292
7	8487	8739	9718	15457	16575	21263	13758	21073
8	4528	5210	5564	5642	10902	10564	14919	11112
9	5551	2799	2297	3957	4194	6743	5954	9429
10	4534	2791	1752	1643	3620	2694	3733	5035
11	1444	2221	1582	1031	1224	2671	1400	3011
2+	202077	190546	201721	222390	231419	241895	288483	334445
3+	158422	157159	168012	180988	171650	201986	265245	281941
4+	127988	103592	134083	133445	106128	145849	212579	233210
5+	66084	72359	72020	98532	71344	96243	134252	160408

POLLOCK CATCH BIOMASS

	1973	1974	1975	1976	1977	1978	1979	1980
2	1448	300	331	416	158	168	213	596
3	2520	10485	4919	4573	2778	3774	5043	3849
4	26151	6320	17711	7883	6157	7357	12380	12978
5	13344	11129	5613	13222	5956	8209	11217	18269
6	3850	5441	6537	4636	9839	6056	8642	10353
7	3514	2611	2775	4334	4778	9554	3197	4613
8	1800	2530	861	1342	3429	3593	2638	2433
9	2605	748	389	178	1112	2388	1145	2064
10	2374	991	510	244	601	1075	543	1102
11	585	825	368	260	364	887	307	659
2+	58391	41489	40015	37092	35174	41520	45525	56714

POLLOCK MEAN AGE OF THE CATCH

	1973	1974	1975	1976	1977	1978	1979	1980
	4.47	4.18	4.26	4.53	4.92	4.97	4.56	4.89

POLLOCK FISHING MORTALITY

	1973	1974	1975	1976	1977	1978	1979	1980
2	0.037	0.024	0.011	0.011	0.003	0.005	0.010	0.013
3	0.096	0.221	0.175	0.112	0.070	0.086	0.112	0.110
4	0.629	0.253	0.379	0.287	0.219	0.173	0.168	0.257
5	0.704	0.435	0.261	0.352	0.322	0.320	0.324	0.375
6	0.441	0.481	0.363	0.271	0.416	0.429	0.346	0.276
7	0.612	0.491	0.376	0.371	0.414	0.588	0.297	0.275
8	0.570	0.749	0.177	0.305	0.427	0.471	0.238	0.246
9	0.731	0.350	0.208	0.051	0.347	0.498	0.259	0.275
10	0.865	0.442	0.386	0.180	0.203	0.282	0.178	0.275
11	0.334	0.522	0.293	0.333	0.395	0.452	0.376	0.275
2+	0.529	0.389	0.263	0.227	0.281	0.359	0.211	0.230

Table 21. Results of a Thompson-Bell yield-per-recruit calculation

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	0.1000	0.225	0.807	3.591	1.000
	0.2000	0.355	1.159	3.260	0.717
F0.1---	0.2754	0.420	1.284	3.057	0.577
	0.3000	0.437	1.310	2.999	0.541
	0.4000	0.491	1.375	2.798	0.426
	0.5000	0.530	1.401	2.642	0.347
	0.6000	0.560	1.411	2.520	0.291
	0.7000	0.583	1.414	2.427	0.250
FMAX---	0.7410	0.591	1.414	2.394	0.236
	0.8000	0.602	1.414	2.351	0.219
	0.9000	0.617	1.413	2.289	0.194
	1.0000	0.631	1.411	2.238	0.175
	1.1000	0.642	1.409	2.194	0.159
	1.2000	0.652	1.407	2.157	0.145
	1.3000	0.661	1.405	2.124	0.134
	1.4000	0.669	1.403	2.096	0.124
	1.5000	0.677	1.401	2.071	0.116
	1.6000	0.684	1.400	2.048	0.108
	1.7000	0.690	1.398	2.027	0.102
	1.8000	0.695	1.397	2.009	0.096
	1.9000	0.701	1.395	1.991	0.091
	2.0000	0.706	1.394	1.975	0.086

Table 22. Results of projection based on average recruitment of 43,037 x 10^2 from 1973-1980, and fishing at $F_{0.1}$.

POPULATION NUMBERS

	1980	1981	1982
2	43037	42302	42302
3	20695	34794	34200
4	27679	15186	25531
5	27184	17519	9612
6	14159	16905	10895
7	5090	8805	10513
8	1877	3165	5476
9	1511	1167	1969
10	340	940	726
11	355	398	534
2+	142228	141182	141808

POPULATION BIOMASS

	1980	1981	1982
2	52504	51608	51608
3	38700	65064	63953
4	62832	34472	57956
5	83455	53783	29507
6	47292	56463	36386
7	21073	36454	43524
8	11112	18739	32417
9	9429	7284	12283
10	5035	7395	5713
11	3011	3374	4955
2+	334443	334636	338302

CATCH NUMBERS

	1980	1981	1982
2	489	481	481
3	1950	3278	3222
4	5718	3137	5274
5	5951	3835	2104
6	3100	3701	2385
7	1111	1928	2301
8	411	693	1199
9	331	256	431
10	140	206	159
11	78	87	128
2+	19280	17600	17683

Table 22.(Cont'd)

CATCH BIOMASS

	1980	1981	1982
2	596	586	586
3	3646	6129	6025
4	12979	7121	11972
5	18269	11774	6460
6	10353	12360	7966
7	4613	7980	9528
8	2433	4102	7097
9	2064	1595	2689
10	1102	1619	1251
11	659	739	1085
2+	56714	54005	54657

FISHING MORTALITY

	1980	1981	1982
2	0.013	0.013	0.013
3	0.110	0.110	0.110
4	0.257	0.257	0.257
5	0.275	0.275	0.275
6	0.275	0.275	0.275
7	0.275	0.275	0.275
8	0.275	0.275	0.275
9	0.275	0.275	0.275
10	0.275	0.275	0.275
11	0.275	0.275	0.275

Table 23. Results of projection based on average recruitment of $43,037 \times 10^3$ from 1973-1980, $F_{0.1}$ for 1980 and a TAC of 40,000 mt for 1981.

POPULATION NUMBERS

	1980	1981	1982
2	43037	42302	42302
3	20695	34794	34322
4	27679	15186	26336
5	27184	17519	10339
6	14159	16905	11778
7	5090	8805	11365
8	1877	3165	5920
9	1511	1167	2128
10	640	940	785
11	355	398	632
2+	142228	141182	145908

POPULATION BIOMASS

	1980	1981	1982
2	52504	51608	51608
3	38700	65064	64182
4	62832	34472	59783
5	83455	53783	31741
6	47292	56463	39338
7	21073	36454	47052
8	11112	18739	35045
9	9429	7284	13279
10	5035	7395	6176
11	3011	3374	5337
2+	334443	334636	353561

CATCH NUMBERS

	1980	1981	1982
2	489	345	481
3	1950	2384	3233
4	5718	2325	5440
5	5951	2849	2263
6	3100	2749	2578
7	1114	1432	2488
8	411	515	1296
9	331	190	466
10	140	153	172
11	78	65	138
2+	19280	13007	18556

Table 23 (Cont'd).

CATCH BIOMASS

	1980	1981	1982
2	596	421	586
3	3646	4457	6046
4	12979	5279	12350
5	18269	8747	6948
6	10353	9183	8612
7	4613	5929	10300
8	2433	3048	7672
9	2064	1185	2907
10	1102	1203	1352
11	659	549	1173
2+	56714	40000	57946

FISHING MORTALITY

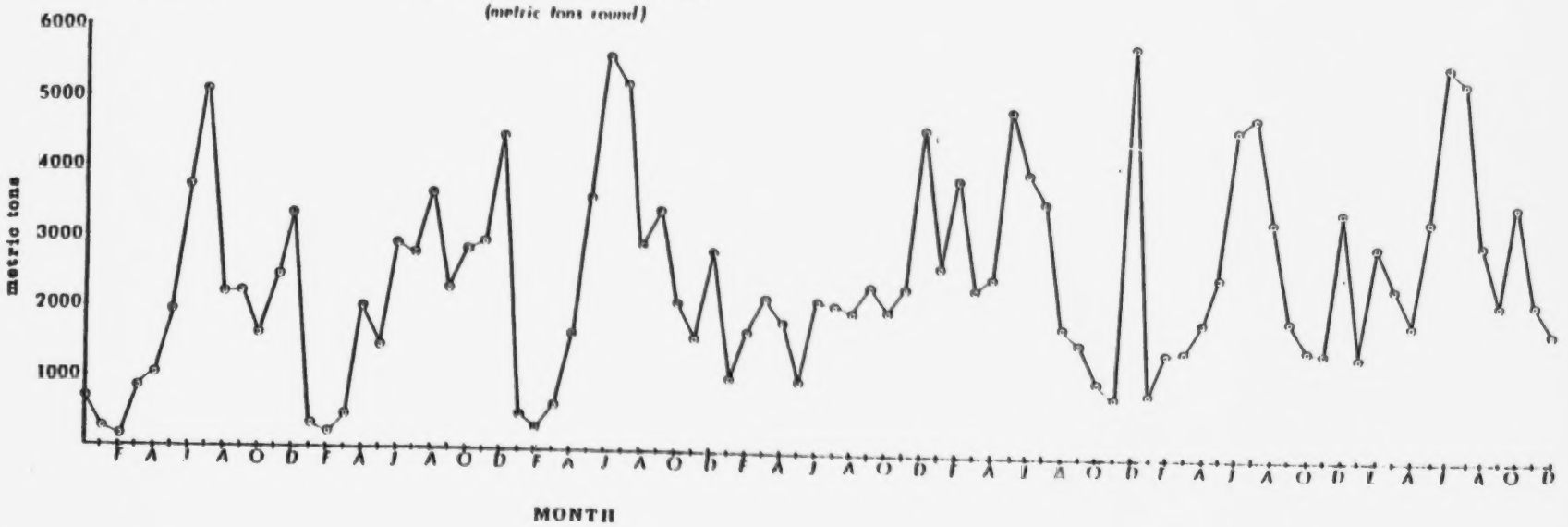
	1980	1981	1982
2	0.013	0.009	0.013
3	0.110	0.078	0.110
4	0.257	0.184	0.257
5	0.275	0.197	0.275
6	0.275	0.197	0.275
7	0.275	0.197	0.275
8	0.275	0.197	0.275
9	0.275	0.197	0.275
10	0.275	0.197	0.275
11	0.275	0.197	0.275

FIG. 1 a

MARITIMES

POLLOCK LANDINGS 1974-1980

(metric tons round)



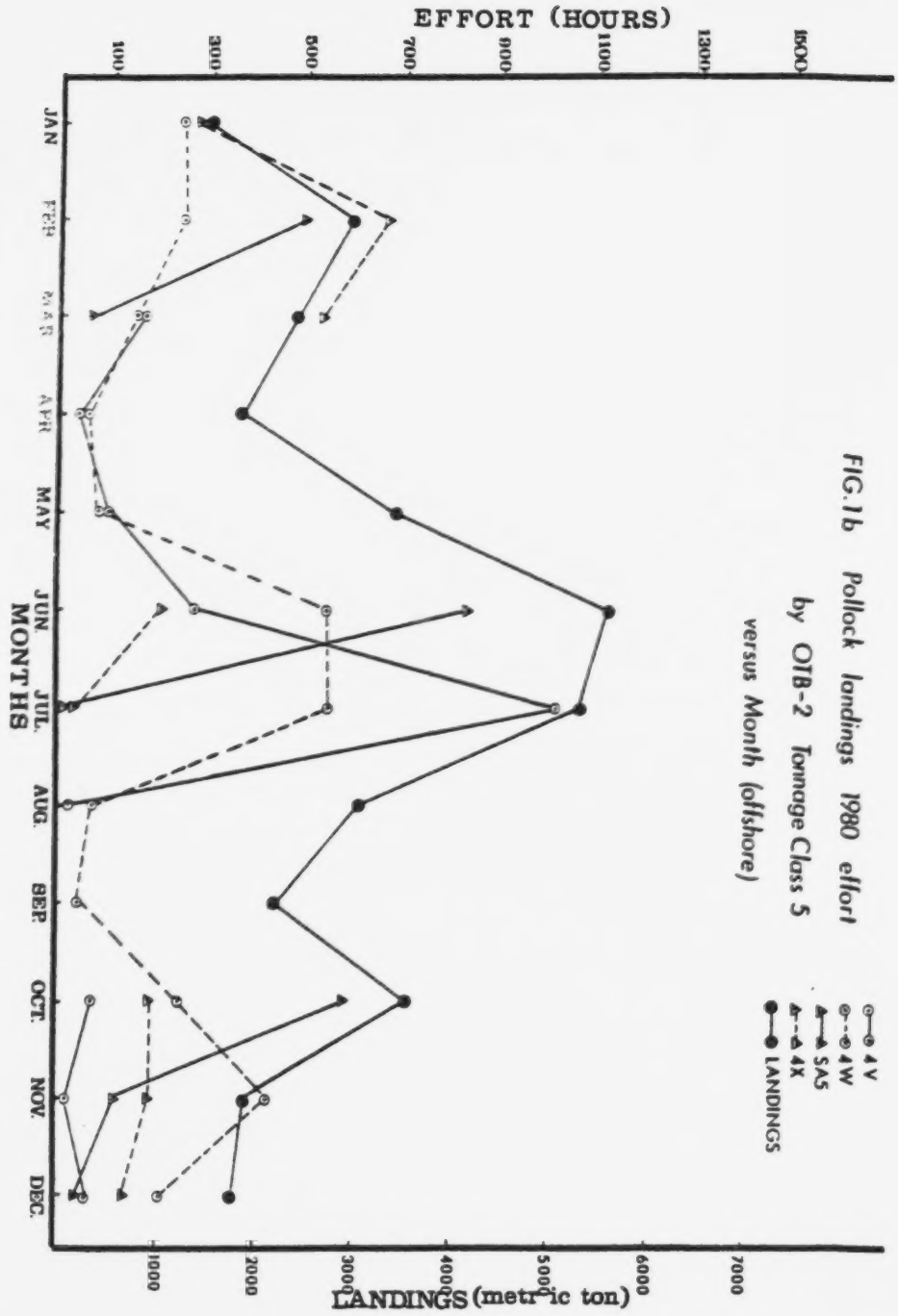


FIG. 1b Pollock landings 1980 effort by OTB-2 Tonnage Class 5 versus Month (offshore)

FIG.2a

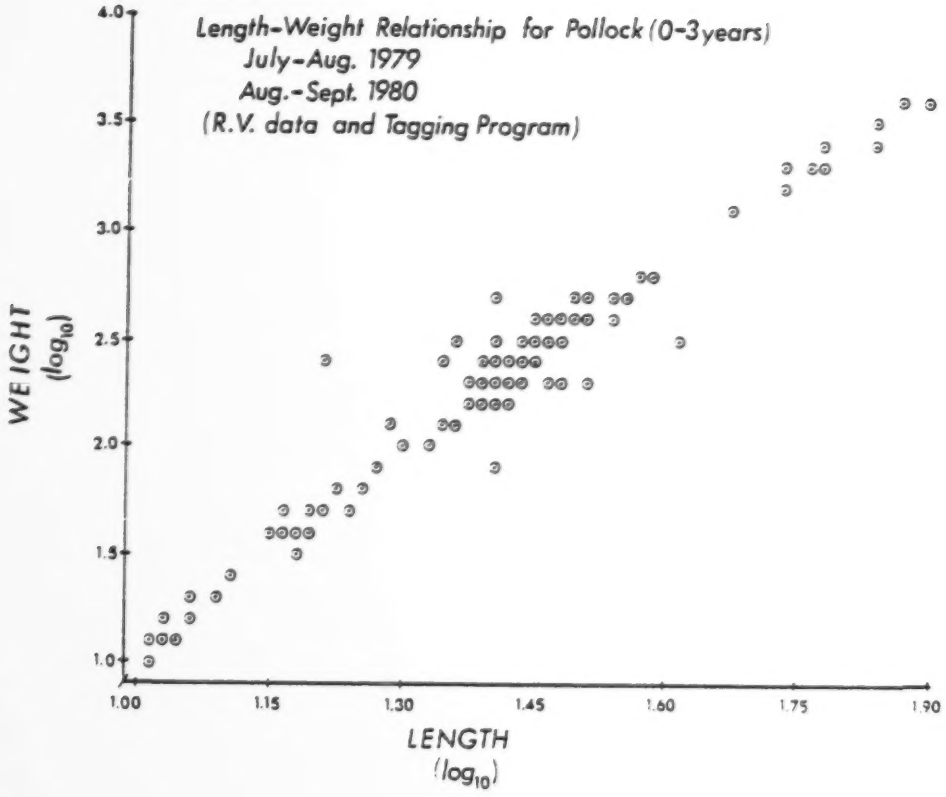

Length-Weight Relationship for Pollock (0-3 years)
July-Aug. 1979
Aug.-Sept. 1980
(R.V. data and Tagging Program)
WEIGHT
(log10)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
1.00
1.15
1.30
1.45
1.60
1.75
1.90
LENGTH
(log10)

FIG.2b

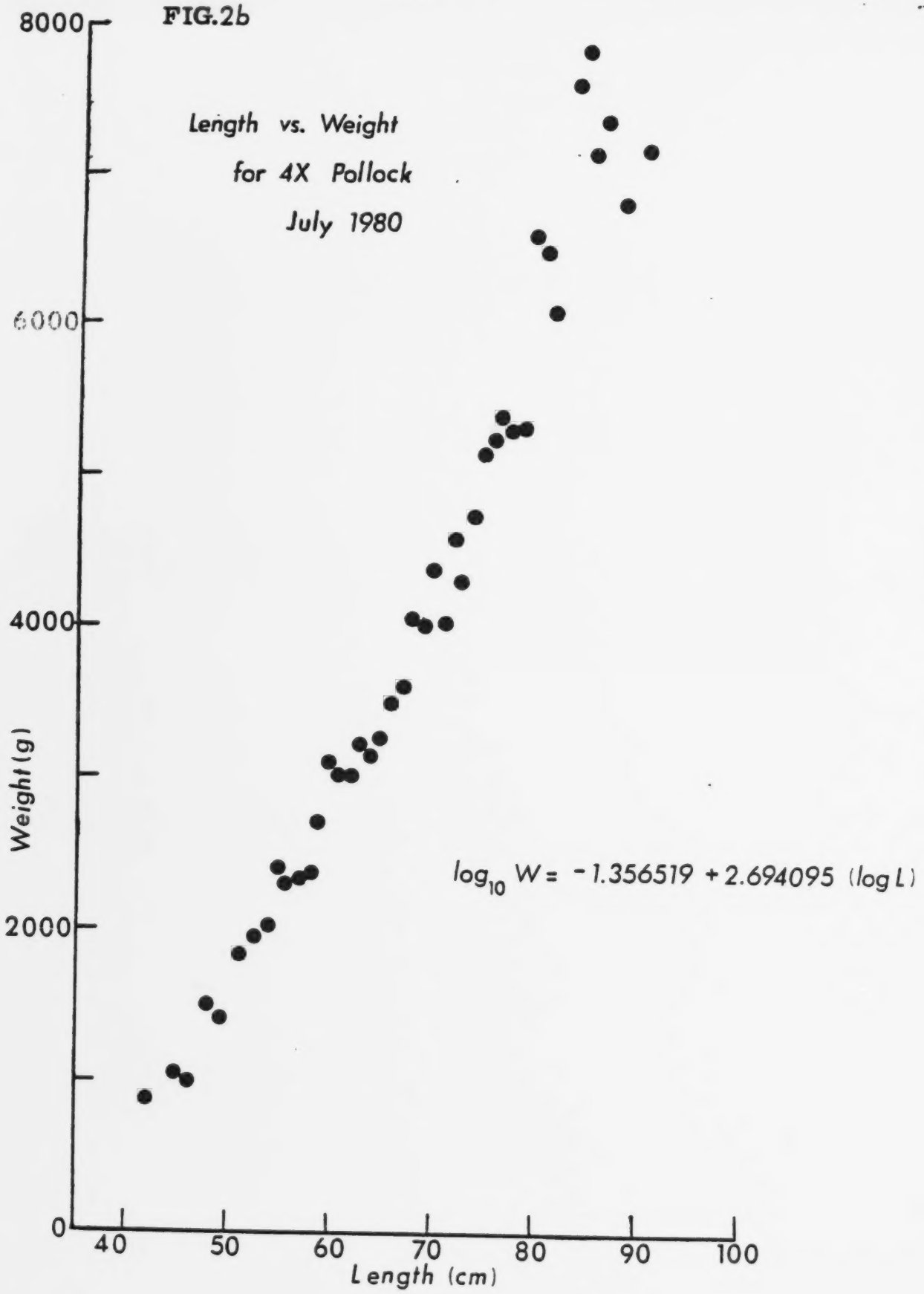

Length vs. Weight
for 4X Pollock
July 1980
8000
6000
4000
2000
0
Weight (g)
40
50
60
70
80
90
100
Length (cm)
$\log_{10} W = -1.356519 + 2.694095 (\log L)$

FIG.2c

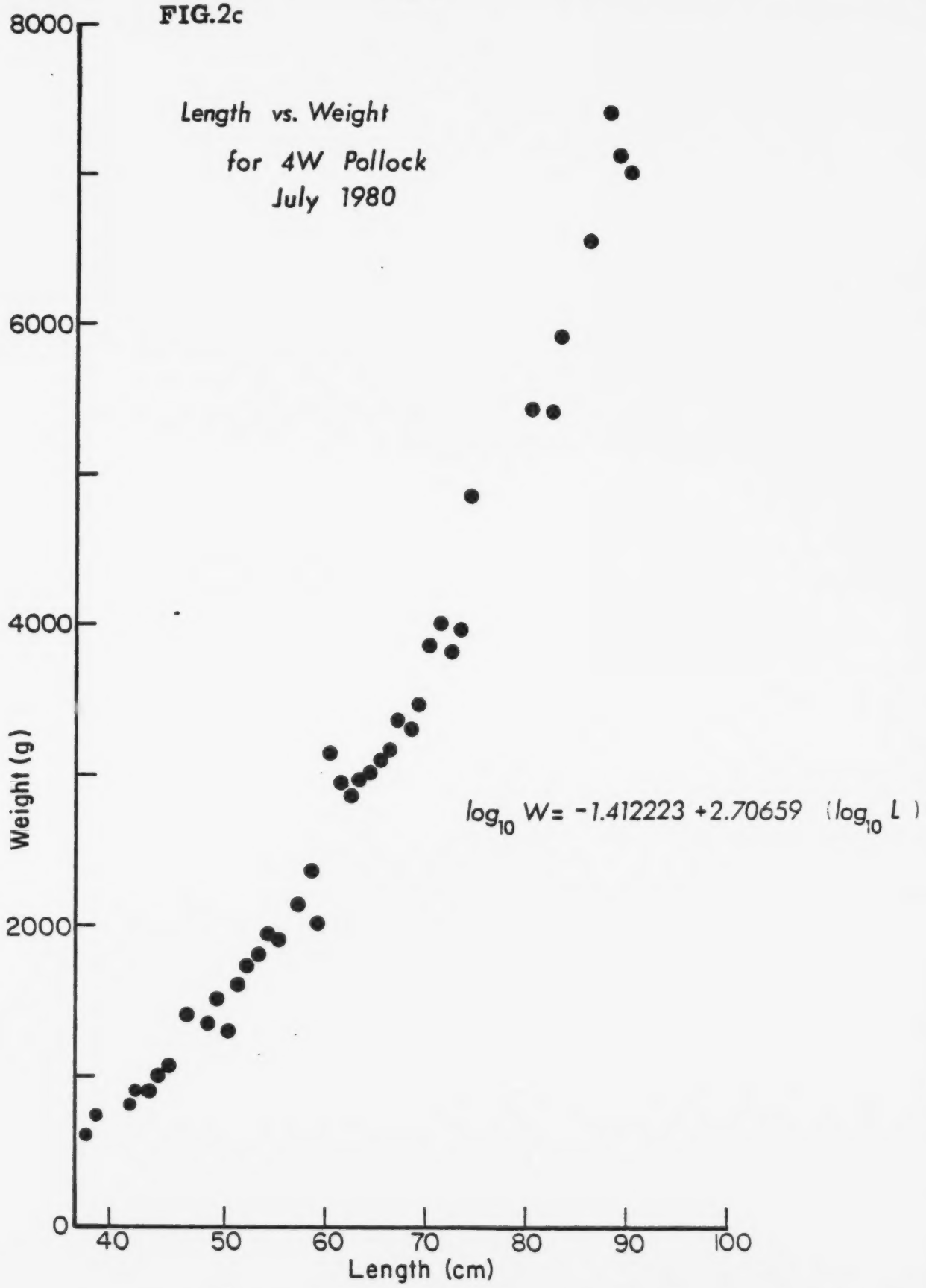
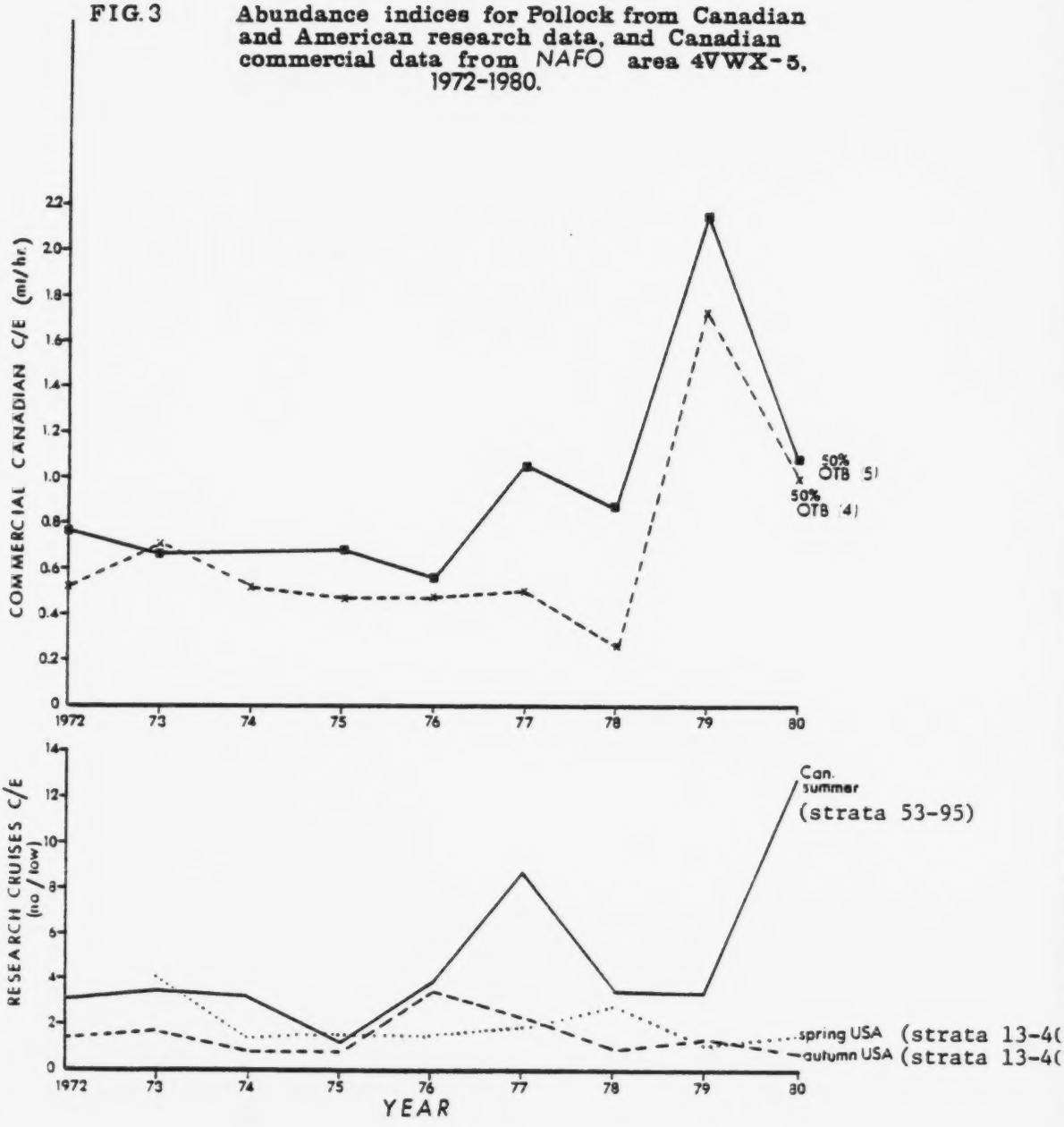

Length vs. Weight
for 4W Pollock
July 1980
8000
6000
4000
2000
0
Weight (g)
40
50
60
70
80
90
100
Length (cm)
log10 W= -1.412223 +2.70659 (log10 L)

FIG. 3 **Abundance indices for Pollock from Canadian and American research data, and Canadian commercial data from NAFO area 4VWX-5, 1972-1980.**



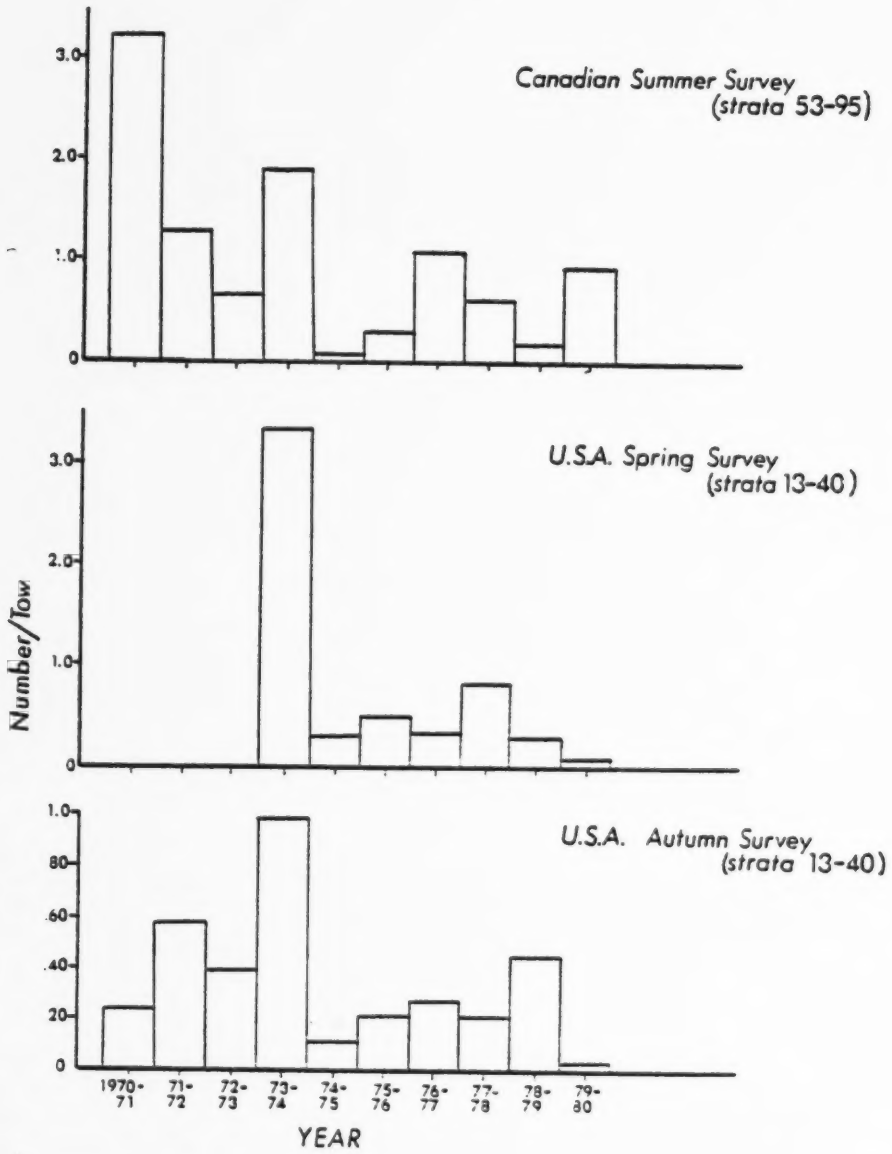


FIG. 4 **Research catch rates at ages 2 & 3 for Canadian and U.S. surveys from 1970-1980.**

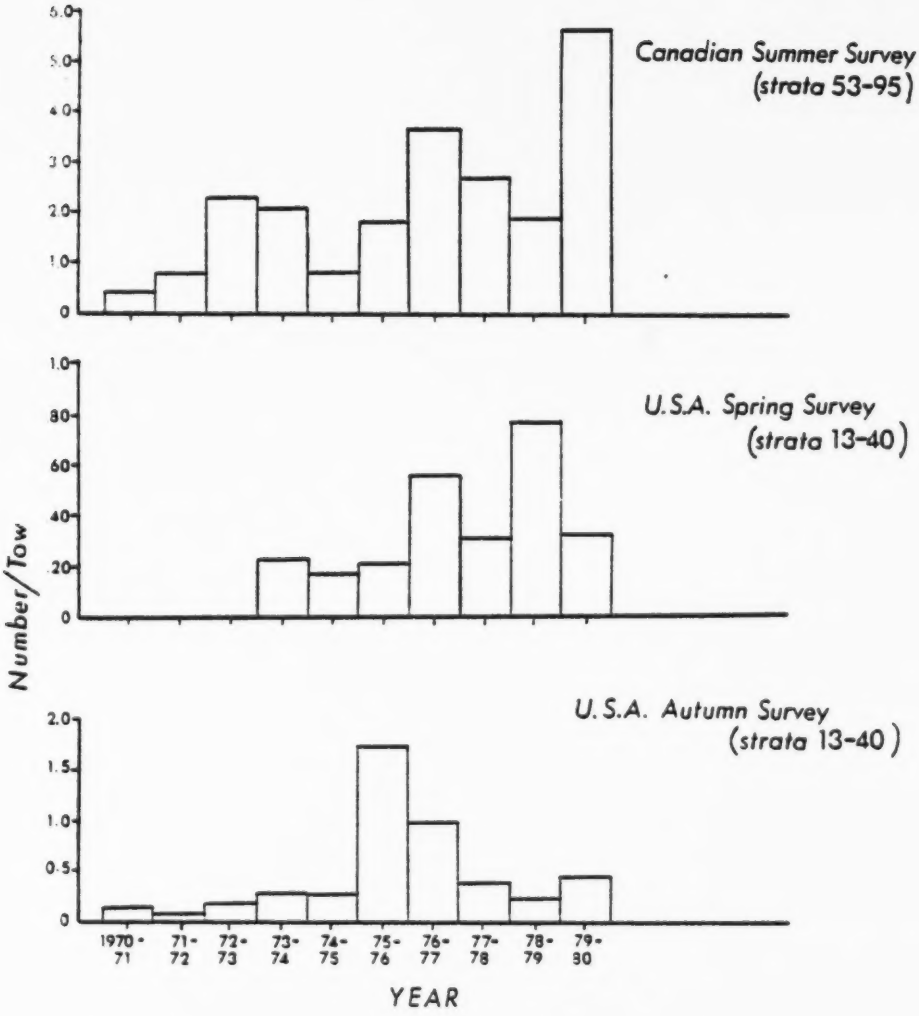


FIG. 5 Research catch rates at age 4 & 5 for Canadian and U.S. surveys from 1970-1980.

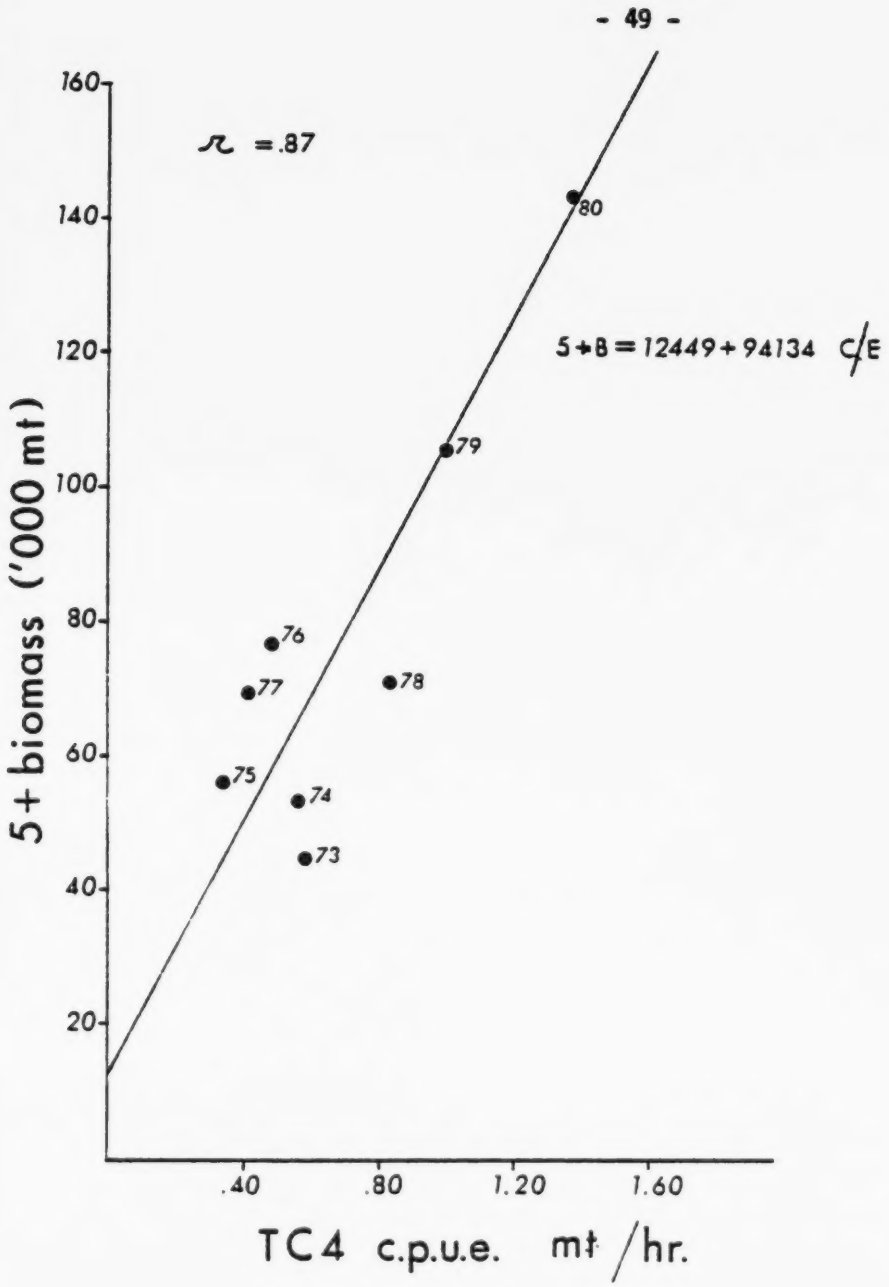


fig. 6 Plot of average 5+ biomass vs c.p.u.e. for tonnage class 4 otter trawlers (1980 point included)

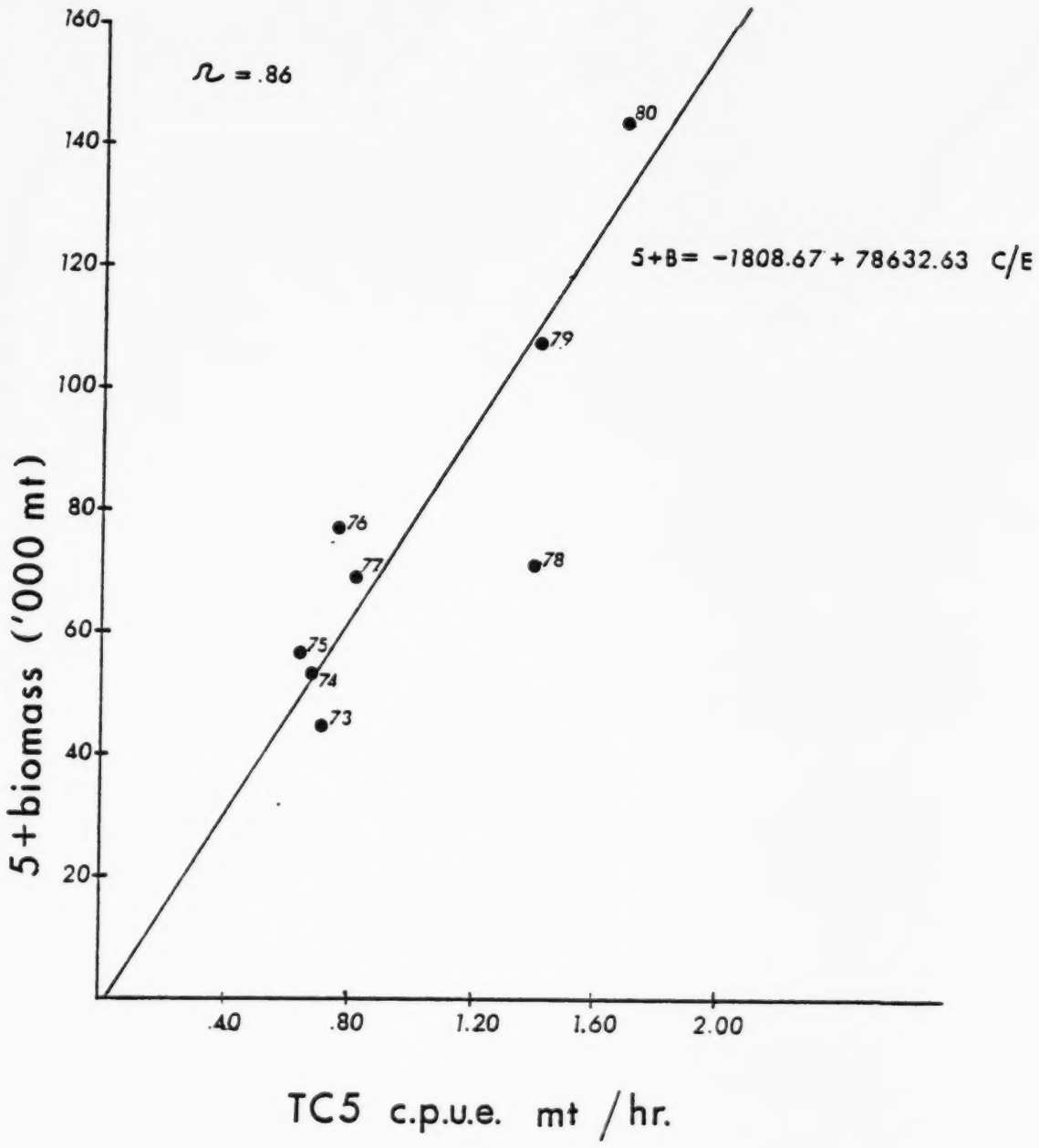


fig. 7 Plot of average 5+ biomass vs c.p.u.e. for tonnage class 5 otter trawlers (1980 point included)